Technical University of Denmark

Strip detector for nanoscale resolution

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The 3D x-ray nano-detector

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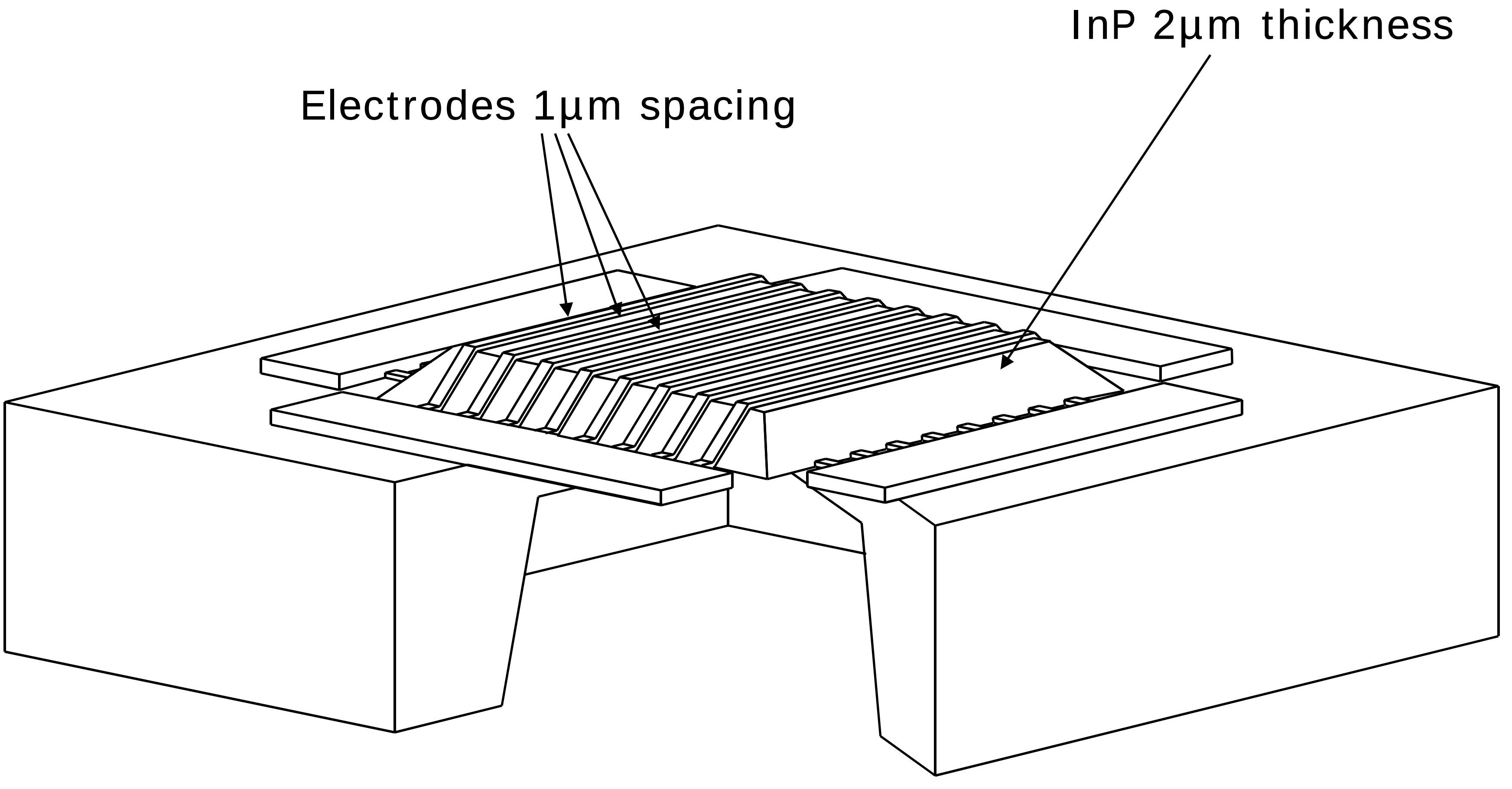
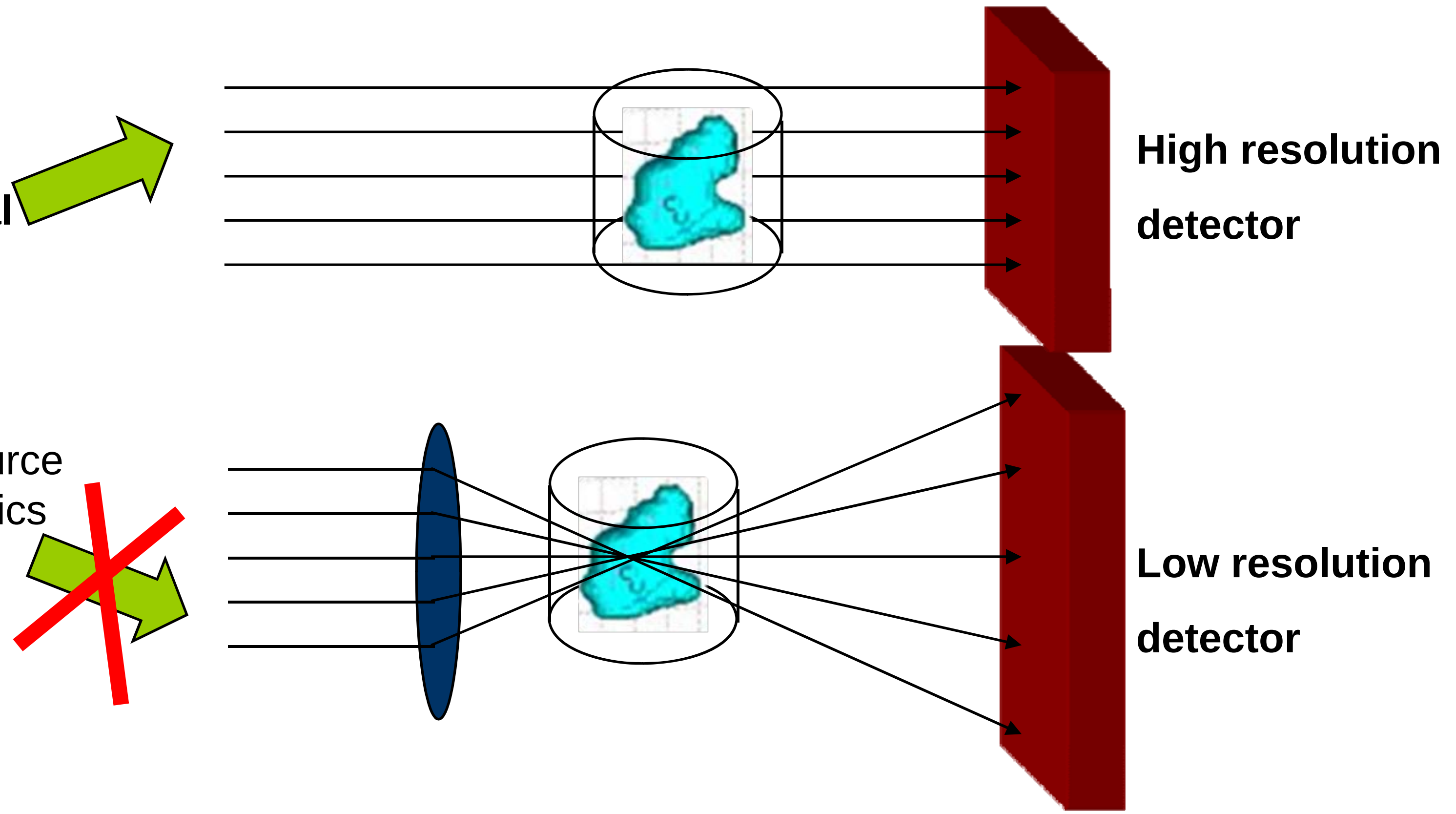
DTU Photonics: Kresten Yvind, Luisa Ottaviano



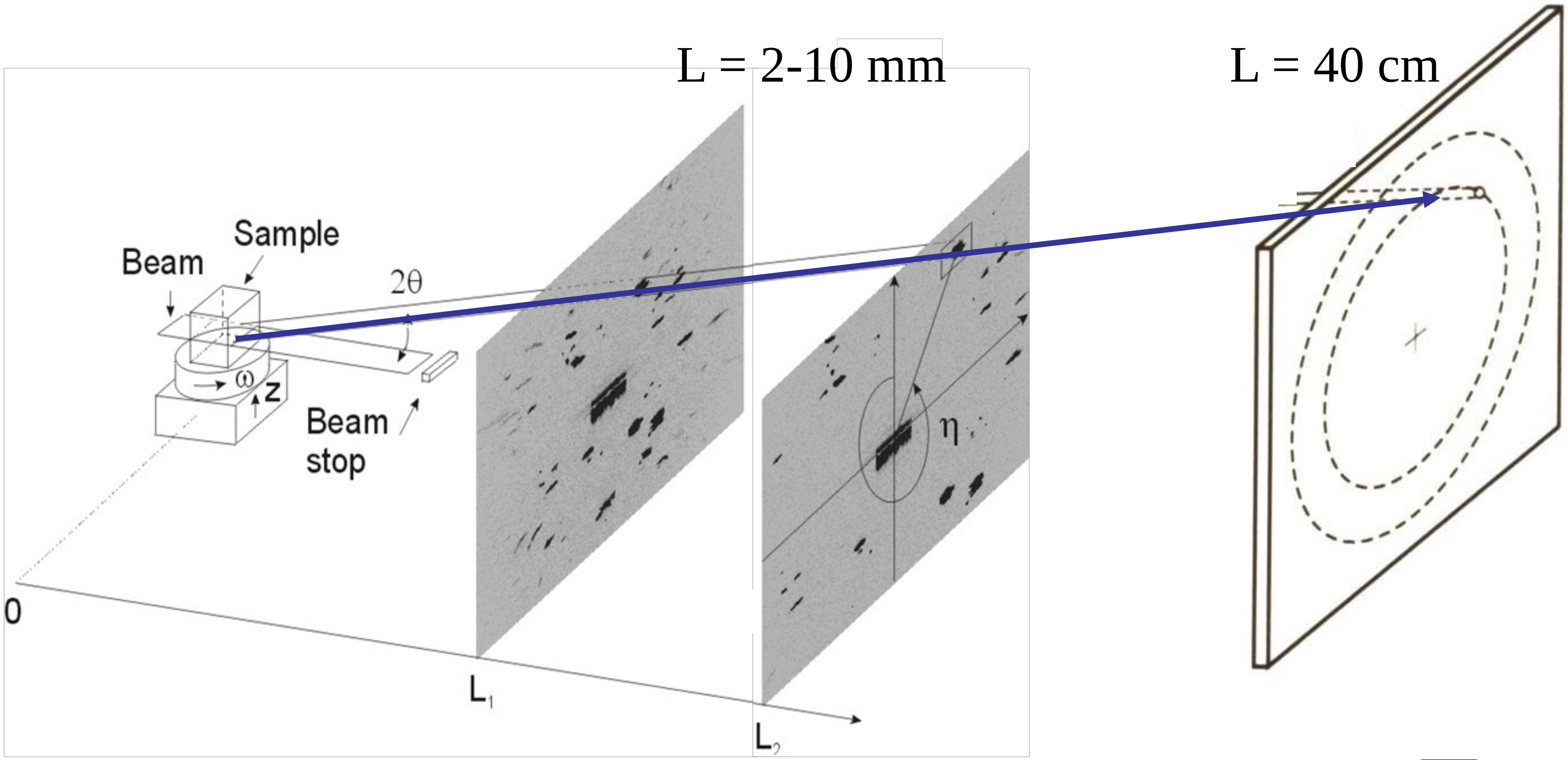
High resolution detectors - why

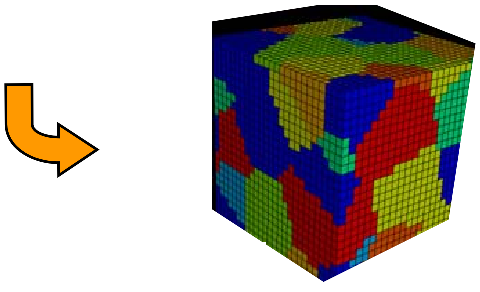
experimental conditions:
white beam
high energy
tight space
non-ideal source
non-ideal optics



3DXRD set-up @ ID11, ESRF

30-80 keV x-rays

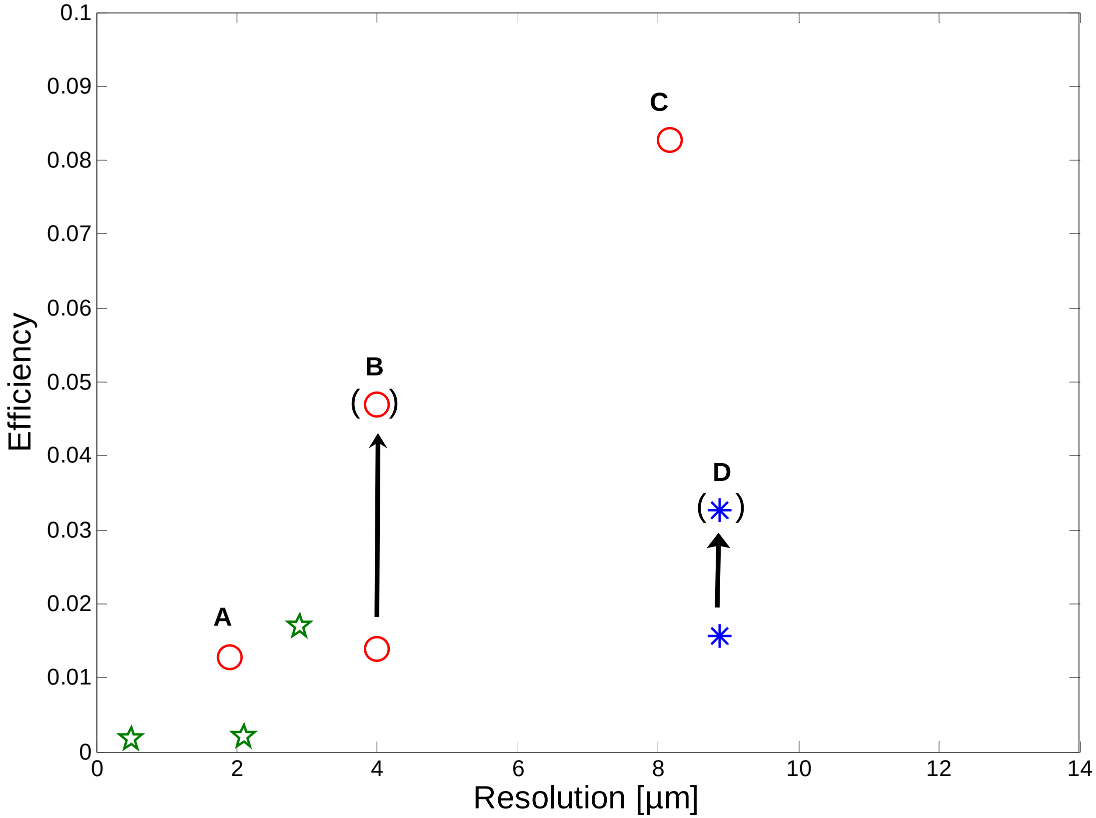


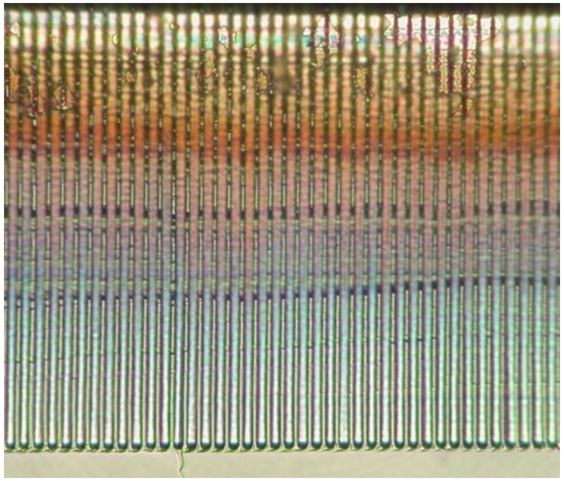


Structured scintillator project

Collab with: KTH , Sweden: X. Badel, J. Linros
ESRF: T. Martin, V. Honkimaki, M. diMichiel

structured scintillators /planar scintillators

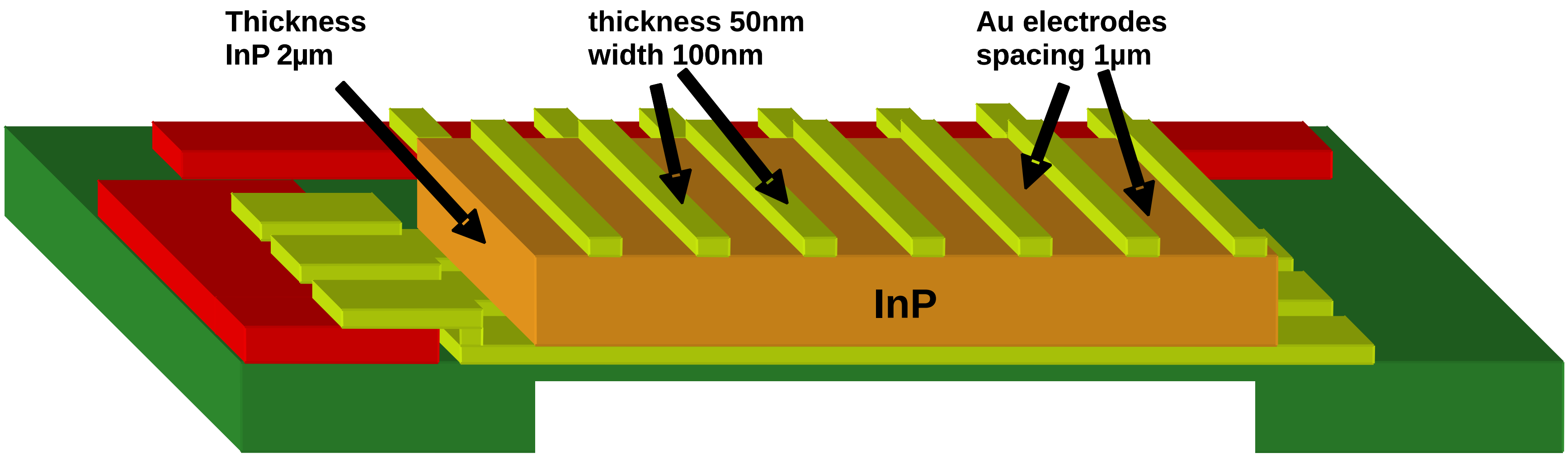




Limitation 1 µm → Nanodetector

sensor design

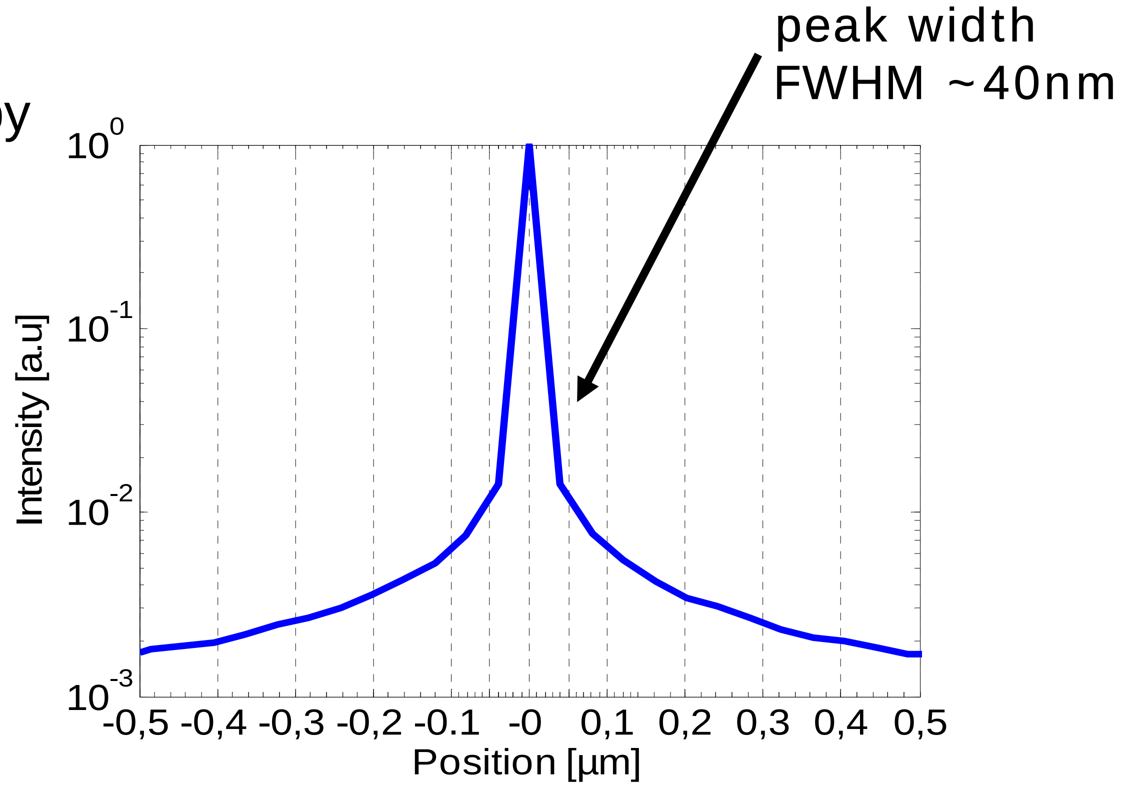
- 1mm^2 active area
- 1µm pitch of electrodes
- 2 orthogonal sets of parallel electrodes
- Electrode dimensions ~50nmX100nmX1mm
- Sensor thickness 2µm -> 10%@10keV



1st order simulation of spatial resolution –e/h pair generation

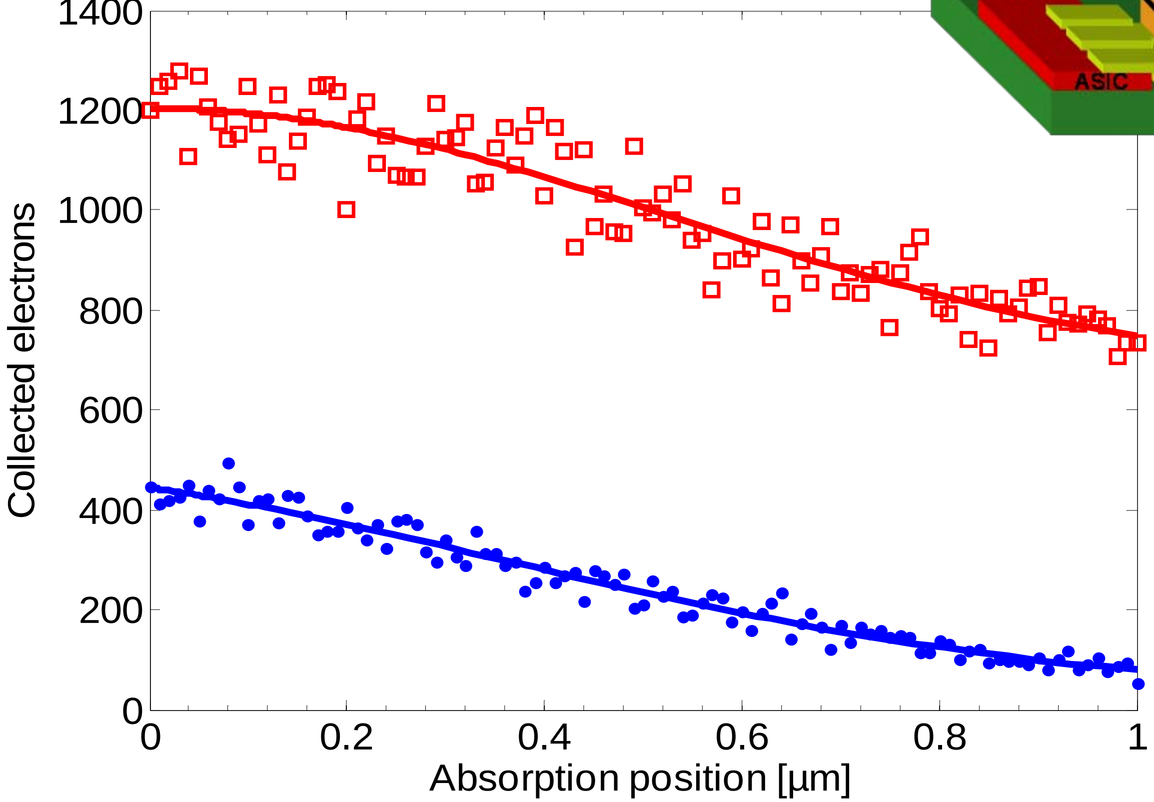
X-ray absorption simulated by MCNP.

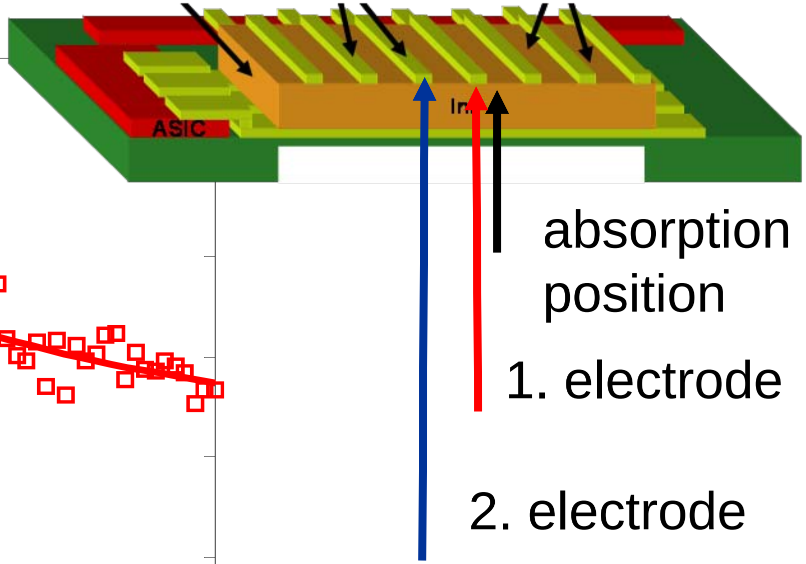
2µm thick sensor
10 keV X-rays



Absorbed Energy Vs Distance from X-ray hit (average of 750.000 photons)

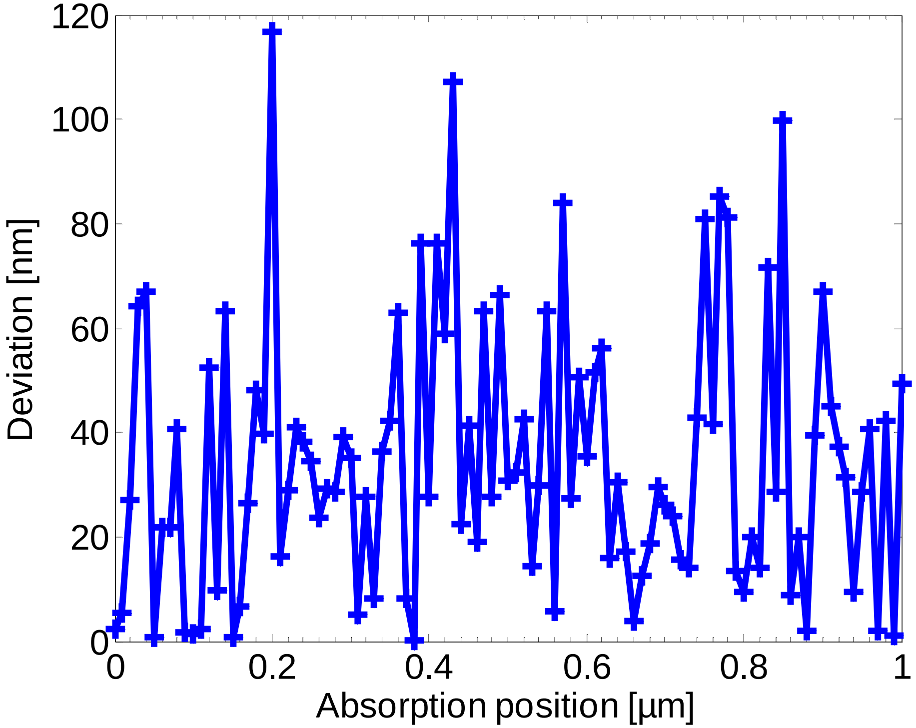
1st order simulation of spatial resolution - drift/diffusion

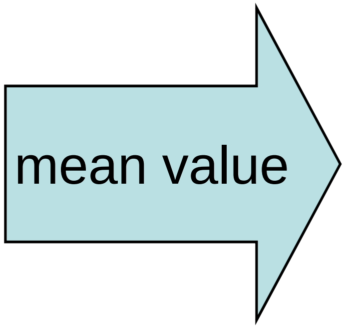




10keV X-ray ~2500 e/h pairs

1st order simulation of spatial resolution - findings





35nm+/- 25nm

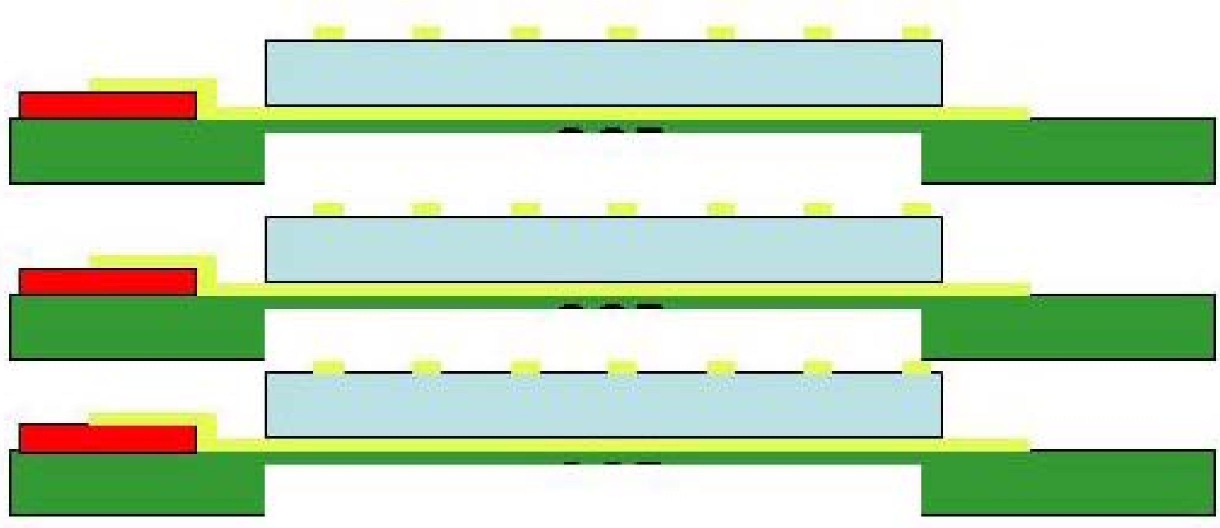
Assumptions:

noiseless electronics

no recombinations

No design optimisation like AC coupled auxiliary electrodes

3D configuration for higher energies



- mutiple layers increase efficiency
- capability of raytracing algorithms (no parallax problem!)
- options for superresolution
- posibilities for more accurate sample alignment

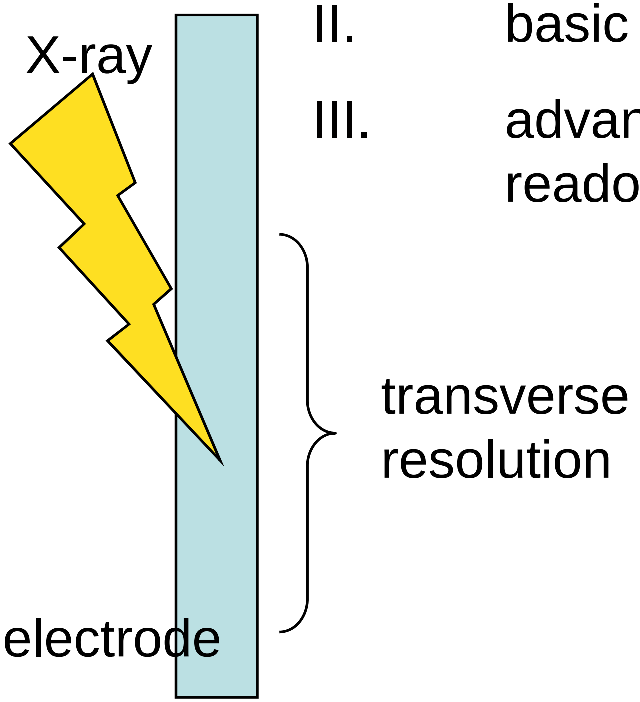
Throughput

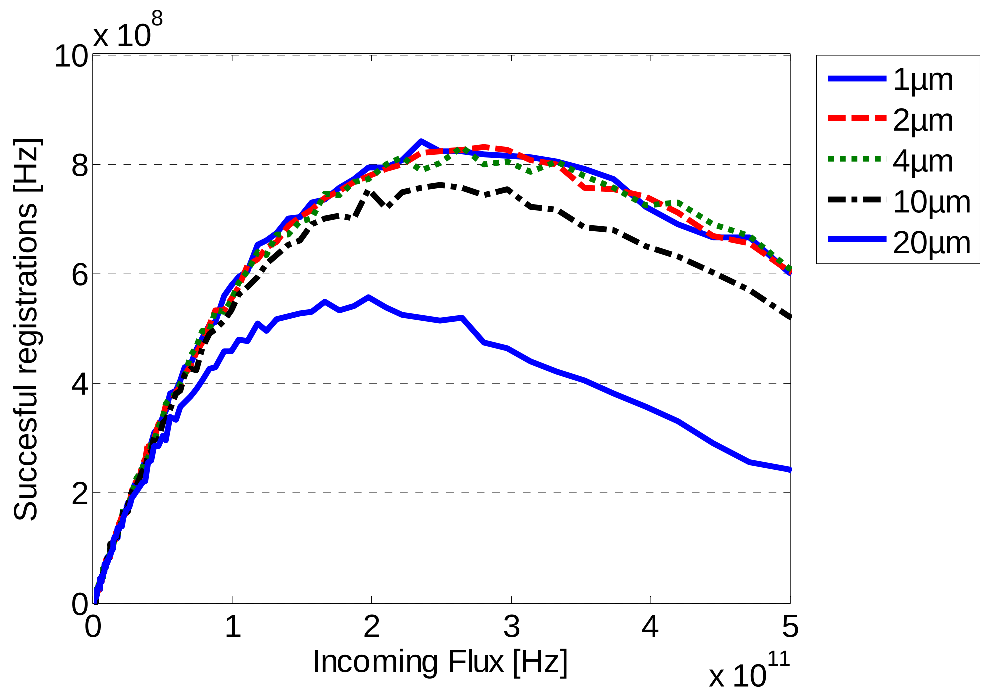
Present ~10k photons/sec on serial 10Mhz read-out

Further development in read-out electronics divided in phase II and III

II. basic parallel electronics: ~5M photons/sec

III. advanced 2D registration using pulse shape or double readout.: increase by 2 orders of magnitude





Timing

Phase I: proof-of-concept

proof of concept funding 1/1 08 – 31/6 09, 2 manyear
Aim: demonstrate 100 nm resolution.

Phase II: 5 MHz 2D detector

Deliverables:

- A prototype detector
- Test of resolution, imaging, stability, throughput
- A report on electronics for Phase III

Manpower: ~ 5 manyears * 3 years Timing: start 2009

Phase III: Detector for XFEL

- Advanced electronics: delay-lines/pulse-shape analysis
- 3D detector

Conclusions

- lens-less single photon detector
- 100nm resolution
- infinite dynamic range
- 1keV-50keV photon energies